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Persistence of, and interrelation between, horizontal and vertical technology alliances

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PERSISTENCE OF, AND INTERRELATION BETWEEN, HORIZONTAL AND VERTICAL TECHNOLOGY ALLIANCES

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ABSTRACT

The authors explore to what extent there is persistence in, and interrelation between, alliance strategies with different partner types (customers, suppliers, competitors). In a panel data set of innovation-active firms in the Netherlands from 1996 to 2004, the authors find persistence in alliance strategies with all three types of partners, but customer alliance strategies are more persistent than supplier alliance strategies and competitor alliance strategies. A positive interrelation between customer and supplier alliance strategies and a high persistence of joint supplier and customer alliance strategies are consistent with the advantages of value chain integration in innovation efforts. Prior engagement in horizontal (competitor) alliances increases the propensity to engage in vertical alliance strategies, but this effect occurs only with a longer lag. Overall, the authors' findings suggest that alliance strategies with different partner types are both heterogeneous in persistence and (temporally) interrelated. This suggests that intertemporal relationships between different types of alliances may be as important as their simultaneous relationship in alliance portfolios.

INTRODUCTION

There is a growing consensus in the literature that a firm's involvement in inter-firm technology alliances matters for its economic and innovative performance (Hagedoorn, 1993; Powell et al., 1996; Ahuja 2000a; Owen-Smith and Powell, 2004). Research on alliances has initially focused on the questions 'why' and 'when' alliances are formed (Kogut and Zander, 1993; Powell and Brantley, 1992). Interdependence and resource complementarities have been addressed here as the most common explanation for the formation of inter-organizational ties (Richardson, 1972; Pfeffer and Nowak, 1976; Harrison et al., 2001). The literature has since broadened significantly and saw the emergence of two streams of research that have focused in particular on interrelationships and alliances between firms. The alliance network literature has focused on the question with which individual partner(s) firms tie up, and the role of network embeddedness and network structural properties herein (e.g. Podolny, 1994; Gulati, 1995a; Gulati and Gargiulo, 1999; Chung et al., 2000). In this way, it has been demonstrated that collaboration with specific partners tends to be highly persistent (Gulati, 1995b; Dyer and Singh, 1998; Mowery et al., 1998; Goerzen, 2007). However, this literature has abstracted from differences in partner attributes and resource complementarities across partner types. The alliance portfolio view, on the other hand, has focused on potential complementarities between different partner types as they bring in different sets of knowledge or complementary capabilities (Lavie, 2007; Vassolo et al, 2004; Lokshin and Duysters, 2008). This literature has focused on specific subsets of partner attributes, such as their relative bargaining power (Lavie, 2007), degree of foreignness (Lavie and Miller, 2008; Lokshin and Duysters, 2008), or their specific technology domain (Sampson, 2007). A conclusion emanating from these studies is that the role of partner attributes may be as important as the role of networks' structural properties (Lavie, 2007; Faems et al, 2005; Belderbos et al, 2004a).

Despite the broadening of the alliance literature and the notion that collaboration with different types of partners is driven by different motives and characterized by different risks and corresponding needs for control (Parkhe, 1993), little attention has been paid to the differences in persistence of, or interrelations between, alliances strategies with different *partner types*. This paper is the first to systematically explore such differences in persistence of, and interrelation between, different alliance types, by distinguishing between alliances with suppliers and/or customers (vertical collaboration) and alliances with competitors (horizontal collaboration), within a context of technological collaboration. Whereas vertical inter-firm relations are seen as spanning differentiated organizations that combine symbiotically to achieve collective ends, horizontal inter-firm relations span similar organizations that combine commensalistically to achieve collective ends (Baum and Ingram, 2002; Tidd et al., 2005). The different partner types play different roles in complementing a firm's own resources and capabilities, related to potentially different goals of the alliances (Faems et al., 2005; Belderbos et al., 2006), which may not only carry differential implications for a firm's proclivity to engage in such alliances but may also yield potential interrelationships between them. Hence, we anticipate differences in persistence as well as interrelationships between alliance strategies with different partner types.

We examine persistence and interrelation of alliance strategies in a comprehensive panel dataset on innovating firms in the Netherlands, 1996-2004. Persistence is defined as the degree to which prior involvement in an alliance strategy predicts current alliance strategy engagement. In contrast to most previous empirical work that relied on alliance press reports, we use official statistical survey data drawn from the harmonized European Community Innovation Survey. An important advantage of this source is the fact that repeated

observations are included on the same firms over longer periods (e.g. 6-10 years), making the data very suitable for analysis of persistence in alliance strategies.[1]

THEORETICAL BACKGROUND

A number of literature streams suggest persistence of alliance strategies through various mechanisms and processes. We review the most important lines of thinking in this section.

First, persistence in alliance strategies can be expected by considering the role of habitual forces and path dependence. Organizations tend to establish routines that are associated with satisfactory performance, which are then replicated and perpetuated, leading to path-dependency in their behavior and strategy (Cyert and March, 1963; Nelson and Winter, 1982; Levitt and March, 1988). Seen in this way, persistence of a certain alliance strategy may be attributable to a firm's reliance on routine action that favors repetition of past action (Li and Rowley, 2002). Persistence will be further reinforced, as suggested by Williamson's remediableness criterion (1999), by the presumption that an established mode of organization (e.g. collaboration) forms an efficient strategy as long as no superior feasible alternatives are present that offer net gains when implemented (e.g. a stand-alone strategy).[2]

The extant literature on interorganizational relations and social capital suggests that network embeddedness is also likely to contribute to persistence of collaboration. Both through relational and structural embeddedness, a firm's network structure forms a key source of information over time that helps to lower search costs and to alleviate risks of opportunism (Granovetter, 1985; Coleman, 1988). This leads to a process of 'structural differentiation' in which firms increasingly come to possess distinct relational profiles and network positions,

[1] We discuss the limitations of the data and our approach in the concluding section.

[2] We note that, on the other hand, routines may become inflexible over time and difficult to change, leading to inertia (Levitt and March, 1988; Feldman and Pentland, 2003; Gilbert, 2005). Hence, although firms may pursue persistent alliance strategies as this may bring benefits, this does not imply that persistence will always carry positive performance effects. As recently shown there may also be a downside to persistence in collaboration in case the external environment changes in radical ways (Koka and Prescott, 2008).

forming an additional source of information on potential partners over time (Gulati and Garguilo, 1999). Persistence of collaboration is attractive as it provides firms with an ongoing stream of information that becomes available by being embedded in a network structure.

Another view on alliances and interfirm collaboration is taken by resource based theory. Resource-based theory emphasizes the development of valuable, rare, inimitable and non-substitutable resources as the basis for competitive advantage and superior innovation performance (Wernerfelt, 1984; Barney, 1991). Following this perspective, a firm's dyadic and network relations are seen as constituting a source of relational rents and competitive advantage (Dyer and Singh, 1998). By means of collaboration, firms can create synergistic combinations of assets, knowledge and/or capabilities that may contribute to lowering the costs and/or increasing the perceived value of their offerings. Leveraging the complementary resources of its alliance partner(s) successfully, however, implies that firms need information about their potential partners and the resources they possess (Gulati, 1995a). The ability to find and interpret information on potential partners, and to carefully discriminate among them, is enhanced by the amount of collaborative experience (Gulati, 1999; Duysters & Heimeriks, 2007**).** In addition, firms with more collaboration experience will also be more desirable as partners, be better able to generate value from partnerships and hence be more likely to engage in future collaboration (Gulati 1995a; 1999; Walker et al., 1997). As a consequence, experience in alliances and inter-firm collaboration may form an important source of relational rents for firms, contributing to its potential for generating supernormal returns (Dyer and Singh, 1998).

Alliances can also contribute to the development of dynamic capabilities that represent a firm's ability to integrate and (re)combine internal and external knowledge and competences in order to strengthen and renew its competitive advantage over time (Teece et al., 1997; Eisenhardt and Martin, 2000; Armstrong and Shimizu, 2007). In this way, persistent use of

alliance strategies may allow companies to maintain a focus on their core domains through in-house specialization while external collaboration may provide them with a window on newly emerging (technological) opportunities that fall beyond their core areas of expertise (Ahuja, 2000b). Depending on their resource deficiency, companies may consider the specialized resources and capabilities as held by suppliers and customers (vertical collaboration) and competitors (horizontal collaboration) and how they may differentially contribute in providing complementarity.

Finally, a governance perspective on alliances is concerned with how collaboration may affect possibilities for appropriability and risks of imitation by indicating that partners may engage in opportunistic behavior (Teece, 1986; Gulati and Singh, 1998; Nooteboom, 2004a; Dhanaraj and Parkhe, 2006). More specifically, such collaborative hazards may be formed by risks of undesirable knowledge spillovers and free-ridership, which are considered (far) higher in horizontal collaboration when compared to vertical collaboration (Ahuja, 2000a). Seen in this way, a governance view sheds some more light on the extent to which partner types differ in their risk profiles, which may possibly carry implications for differences in persistence of and interrelation between horizontal and vertical alliances.

Most of the literature has not given specific attention to differences in alliance strategies depending on the type of partner. Vertical and horizontal alliances have both been subject of investigation in prior research, but two streams of literature appear to have developed in relative isolation. In the literature on technology alliances, most studies have not made an explicit distinction between types of alliance partners or have restricted analysis to horizontal alliances within an industry (Mowery et al., 1996, 1998; Rowley et al., 2000; Ahuja, 2000a, 2000b; Sampson, 2007). In contrast, the supply chain literature has largely focused on vertical alliances with suppliers or customers (e.g. Lee et al., 1997; Rosenzweig et al., 2003; Vickery et al., 2003). The objectives and performance effects of vertical alliances have also been

found to differ from those of horizontal alliance with the latter frequently focusing on more radical innovations and the former on cost reduction or on reducing time to market (Belderbos et al, 2004a; 2004b; Tether, 2002). Although it has been demonstrated that collaboration with customers and/or suppliers as well as with competitors can be (highly) beneficial for firms (e.g. Von Hippel, 1978; Frohlich and Westbrook, 2001; Ahuja, 2000b), the interrelationships between these alliances strategies or partner type specific persistence have not been subject of research until now.

DATA AND METHODS

The empirical analysis uses a panel data set constructed from five consecutive European Community Innovation Surveys (CIS) conducted in 1996, 1998, 2000, 2002 and 2004 by the Central Bureau of Statistics (CBS) in the Netherlands. The sampling methodology and the harmonized questionnaire are described in the OECD Oslo Manual (OECD, 1997). The CIS surveys contain data concerning R&D expenditures and innovation activities of the firm, and engagement in collaborative technology development distinguished by partner type. The technology alliances in the survey relate to joint development efforts and collaboration on R&D. Since we are interested in the persistence of technology alliances, our analysis is naturally confined to firms engaging in innovative activities for which technology collaboration is relevant. An important advantage of this source is the fact that repeated observations are included on the same firms over longer periods (e.g. 6-10 years), making the data very suitable for analysis of persistence in alliance strategies. Another advantage is the diversity of firms included in the data: both large R&D intensive firms as well as small and medium sized enterprises are included, and the data cover a wide spectrum of industries. Hence, use of this dataset avoids the problem of oversampling of large firms and the lack of systematic information on alliance disbandment, which has hampered prior research using data on alliance announcements (Schilling, 2009). On the other hand, we note the limitations

of this extensive longitudinal dataset in that it does not reveal identities of individual partner firms or the number of alliances of each type. For our purpose, the analysis of differences in persistence and interrelationships between alliance strategies with different partner types, these drawbacks pose fewer problems.

The sample includes 4632 observations on 3181 innovating firms from a wide range of sectors (we distinguish 17 sectors at the 2-digit level). Each observation requires that the firm has responded in three consecutive survey years, as this is required to examine persistence in our empirical model. Given the partially random sampling in each year for smaller firms, we do not often observe each firm for the entire period (1996-2004) and the panel is unbalanced in nature.[3]

Measures

Technology alliances. The CIS surveys ask if the firm had any cooperation arrangements on innovation activities with other firms in the last 2 years. Cooperation agreements are then differentiated by the type of partner such as customers, suppliers, and competitors. Based on this question, we create three dependent variables taking the value one if a firm reported to be engaged in a particular type of alliance, i.e. customer, supplier or competitor, and zero otherwise[4]. We define persistence as the degree to which prior involvement in alliances with a specific partner type predicts current involvement in such alliances. This approach follows the definition of persistence as 'state dependence' (e.g. Heckman, 1981), which in our context means that being engaged in past alliance activities increases the probability to be engaged in these activities currently. A similar approach has been used to analyze persistence in profits (Mueller, 1977; McGahan and Porter, 2003),

[3] A balanced sample only leaves 591 observations. Results on this strongly reduced sample gives qualitatively similar results.
[4] It is possible that especially large firms have multiple technology alliances of a particular alliance type. The CIS surveys however do not contain information on the number of alliances per type.

innovation (Roberts, 1999; Raymond et al., 2010) or other measures of firm performance such as Tobin's q (Villalonga, 2004). We examine persistence and interrelation by including as covariates dummy variables measuring past engagement in technology alliances as reported in the previous surveys conducted two and four years earlier. We note that, although the surveys ask for alliance engagement in a 2-year period, we cannot entirely rule out that there are (short-lived) 'gaps' between alliance engagement in t and t-2, and likewise t-2 and t-4, as firms may also dissolve an alliance within the survey period. Hence, we define persistent alliance strategies as recurrent engagement in a particular alliance type in three consecutive 2-year periods. While the coefficients on prior involvement in the same type of alliance indicate persistence, the coefficients on prior involvement in the other two types of alliances indicate interrelation (see equation 1 below).

As control variables, we include *R&D intensity* (the share of R&D employees in total employment) and its squared term. R&D engagement increases a firm's capacity to recognize, value and assimilate external knowledge from alliance partners (Cohen and Levinthal, 1990; Kim, 1998; Mowery and Oxley, 1995). In this way, more R&D-intensive firms are also more likely to engage in several technological collaboration projects but with diminishing propensity (Belderbos et al, 2004b). The analysis also controls for *firm size*. The literature indicates that the size of companies plays a role in propensity to be engaged in collaboration. Larger firms have more abundant resources and may find it less problematic to handle multiple innovation objectives and management of multiple technology collaborations (e.g. Belderbos et al., 2006; Cohen and Klepper, 1996; Harrigan, 1988). We include the logarithm of the number of employees. R&D intensity and firm size are taken from the (t-2) survey. We also include *firm age*. Older companies tend to be more experienced and will have well-established routines in place (Nelson and Winter, 1982; March, 1988), also specifically geared to collaboration, which may positively affect their propensity to be engaged in

collaboration. On the other hand, well-established routines and abundant experience may also make that firms tend to become more self-reliant (Tidd et al., 2005), which reduces their propensity to be engaged in external collaboration. Furthermore, we control for whether the firm is an affiliate of a *foreign multinational firm* or part of a larger *domestic group*. Firms that are part of a larger group may draw on group financial and technological resources and reputation to make them more attractive as cooperation partners and to support collaborative efforts (e.g. Ahuja, 2000b). At the same time such firms may have fewer incentives to cooperate with outside partners, as they are likely to have intra-group R&D collaboration opportunities.

Finally we include a set of time dummies and industry dummies (16 at the 2-digit industry level) as the need for technology collaboration and the use of particular alliances types may differ across industries and across years. We also include eleven region (province) dummies as the opportunity for collaboration arising from, for instance, differences with regard to innovation activity or clustering of suppliers may vary systematically across locations (e.g., Audretsch and Feldman, 1996).

Descriptive Statistics

Table 1 provides descriptive statistics and lists correlations between the variables used in the estimation. Table 1 indicates that supplier collaboration is most frequently adopted, with 13.1 % of the cases, followed by customer collaboration (10.1 %) and competitor collaboration (6.6 % cases). In addition, 8.3% of the firms are engaged in both supplier and customer collaboration, indicating a relatively frequent use of such combined supplier and customer alliances. The percentages are comparable for current and past alliances. The R&D intensity of the firms in the sample is on average 3.1 percent. The table does not indicate multicollinearity problems for the set of independent variables, Apart from the naturally high

correlation between R&D and its squared term and the negative correlation between the orthogonal group affiliation and MNE affiliation dummies, the highest correlation coefficient is 0.59.[5]

Insert table1 about here

Empirical Methods

In order to analyze the determinants of the persistence of and interrelationships between alliance strategies with the three types of partners, we estimate a multivariate probit model with the dummy variables 'competitor alliance', 'customer alliance' and 'supplier alliance' as dependent variables. The error terms of the three individual probit equations are likely to be correlated if firms are simultaneously considering decisions to engage in the three types of alliances. Use of the multivariate probit model in which we simultaneously estimate the propensity to be engaged in alliance strategies with the three partner types addresses this problem and leads to an improvement in the efficiency of the estimates.

Given that we analyze unbalanced panel data, we also estimated probit equations for each alliance type using panel probit estimators with random effects.[6] The estimates from these individual equations are consistent, albeit not efficient because they do not take correlation between equations into account. We used a likelihood ratio test to test the significance of the panel-level variance component (rho) in the total variance. In the customer and competitor equations we could not reject the null hypothesis that rho is zero at any conventional level. In the supplier equation the null hypothesis could not be rejected at the 5 percent level but was just rejected at the 10 percent level. Overall, these results indicate that

[5] We also examined multicollinearity through the condition number of the matrix of regressors. This statistic (the ratio of largest to smallest eigenvalue) is an unbounded measure of collinearity, or ill-conditioning, in the data (Belsley, 1991). These diagnostic measures did not indicate problems of collinear regressors in our models.
[6] Fixed effects probit estimator produces inconsistent estimates due to so called 'incidental parameters problem' (Wooldridge, 2002, p. 484).

the panel-level variance component is only of marginal importance and that the pooled multivariate probit estimators are to be preferred over the random effects estimator. The implication is that we could proceed by estimating the equations as a multivariate probit system. The system of equations is given in equation (1).

$$y_{it,k} = \begin{cases} 1 \, if \; \beta_{1,k} CUS_{it-2,k} + \beta_{2,k} CUS_{it-4,k} + \beta_{3,k} SUP_{it-2,k} + \beta_{4,k} SUP_{it-4,k} + \beta_{5,k} COM_{it-2,k} + \beta_{6,k} COM_{it-4,k} \\ + \mathbf{Z}_{it-2,k} \theta_k + \omega_{it,k} > 0 \\ 0 \, otherwise \end{cases}, \quad k = 1,...,3; i = 1,..., N; t = 1,...,5 \tag{1}$$

where *i* indexes firms and *t* years, accordingly; $y_{it,1}$, $y_{it,2}$, and $y_{it,3}$ are the binary indicators which take the value one if a firm reported to be engaged in an alliance with customers, suppliers and competitors, respectively, and zero otherwise. CUS, SUP, and COM measure alliance engagement in the previous two surveys: t-2 refers to the survey 2 years before, and t-4 refers to the survey 4 years before. The size and significance of the coefficients on the past alliance for the same type variables indicate the degree of persistence of alliance strategies with each partner type. The error term ω_{it} in equation 1 is assumed to be random in each of the three equations, and the vector **Z** contains our control variables. The coefficients to be estimated, $\beta_{1,k}$ through $\beta_{6,k}$, are not constrained across the three equations, but the model allows us to test whether the determinants of the alliance strategies of each type are significantly different across equations.

An important issue in the empirical analysis is potential endogeneity biasing our results. It has been noted that this type of selection bias is of particular importance in performance studies since managers' decisions are endogenous to their expected performance outcomes (Hamilton and Nickerson, 2006; Leiblein et al; 2002; Leiblein and Miller, 2003; Shaver, 1998; Argyres, 1996). In the context of our analysis, it is possible that some

unobserved firm specific factors affect the propensity to be engaged in alliances and/or specific alliance types, such that firms are 'selected in' persistent alliance strategies. The effect of past engagement in alliances with specific partner types on the current probability to be engaged in an alliance strategy with specific partner types then could in theory be a corollary of this selection effect rather than a real persistence effect. In our analysis, we expect this bias to be limited or non-existent, for a number of reasons. First, potential selection effects due to unobserved heterogeneity are mitigated by the use of a wide set of firm-specific control variables that affect the propensity to be engaged in specific alliance types. Second, while remaining selection effects cannot be entirely ruled out, this may potentially lead to an upward bias in the persistence effects, but it is not evident why it would lead to systematic *differences* in persistence across alliance partners, nor is it evident that this should affect patterns of interrelation between alliance strategies with different partner types. Third, one would expect that estimation with firm individual effects would control for the relevant unobserved firm characteristics that may drive longer term selection into alliance types. As we note in the paper, tests of random effect estimators show that these random effects are jointly insignificant (the random effects model is rejected in favor of the multivariate probit), again suggesting that unobserved heterogeneity leading to selection is not likely to bias our results.

EMPIRICAL FINDINGS AND INTERPRETATION

Table 2 reports the results from the multivariate probit explaining the propensity of firms to be engaged in alliance strategies with the three types of partners. The appendix contains the results of a separate probit model explaining the propensity to be engaged in (vertical) value chain spanning alliance strategies (supplier and customer alliances combined).

A first observation from Table 2 is that the correlation coefficients of the error terms in

the multivariate probit model (Rho) are positive, ranging from 0.5 to 0.8, and highly significant. This supports the notion of interdependence between the decisions to be engaged in alliance strategies with different partner types and confirms the need to use the simultaneous equations approach.

Insert table 2 about here

The estimated coefficients indicate a varied pattern of persistence and interrelation with generally positive coefficients, although not all of these are statistically different from zero. We can identify three stylized patterns in the empirical results, with one pattern on differences in persistence and the other two patterns applying to the interrelations between alliance strategies with different partner types.

First, *alliance strategies with different partner types are persistent, but in different degrees.* The coefficients on the corresponding past alliance variable for t-2 (listed on the diagonal of Table 2) are significant in each of the three equations. In addition, the coefficient on (t-4) lagged alliances is significant in the customer equation and marginally significant in the competitor equation, but not in the supplier equation. Hence, there is persistence but the strength of it differs between partner types. The coefficients support a significantly greater persistence of customer alliance strategies compared with the other two alliance strategies. A t-test rejects the null hypothesis that the sum of the coefficients of the t-2 and t-4 own lagged terms in the customer equation is equal to the own lagged terms in the supplier equation (0.51, $p<0.01$) and the competitor equation (0.38, $p<0.05$).

For customer alliance strategies, the persistence effects are also significantly stronger than interrelation effects. T-tests reject that the sum of the past customer alliance coefficients is equal to the sum of coefficients of past supplier alliance strategies (0.65, $p< 0.01$) and past competitor alliance strategies (0.54, $p<0.01$). On the other hand, in the supplier and

competitor equations t-tests do not reject equality of the coefficients of the own lagged terms and the coefficients of the other alliance strategies. Hence, we conclude that persistence effects for the same alliance strategy are not necessarily more pronounced than the interrelation effects between alliance strategies.

Furthermore, two distinct interrelation patterns emerge from the empirical results. A first interrelation pattern emerging from the results is a *positive interrelation between supplier and customer alliance strategies*. Supplier alliances in t-2 have a significantly positive impact on the propensity to be engaged in a customer alliance strategy, and vice versa. In addition, past customer alliances in t-4 have an additional positive impact on the propensity to engage in supplier alliance strategies, although there is no significant effect of supplier alliances (t-4) on customer alliances. Overall, these findings are indicative of a strong interrelation between vertical alliance strategies with both partner types, with the strongest and consistent impact found for recent past alliances (t-2).

The second interrelation pattern is a *positive* interrelation *between vertical and horizontal alliance strategies, but with a longer lag*. The results show that recent past competitor alliances (t-2) have no impact on the propensity to be engaged in a supplier or customer alliance strategy. In contrast, if we examine past alliances with a longer lag (t-4), the results do show a significant impact of past competitor alliances on the propensity to be engaged in an alliance strategy with suppliers or customers (Table 2). These results (which are corroborated in an analysis of the probability to be engaged in joint supplier and customer alliances presented in the Appendix) show that past engagement in alliances with competitors increases the propensity to be engaged in an alliance strategy with customers or suppliers, but that this interrelation effect only occurs with a longer lag (t-4) when compared to the interrelationship between collaboration with suppliers and customers (which is strongest for t-

2).[7] In addition to the patterns described above, the empirical results also show that the propensity to engage in competitor alliance strategies increases due to past customer alliances (t-4) and recent past supplier alliances (t-2).

Among the control variables, firm size is positive and significant in each of the equations. The effect of R&D intensity on the propensity to be engaged in technology alliances is curvilinear in all equations, with a declining marginal impact for high R&D intensities. Age carries a small, negative effect that may reflect a decreasing propensity to be engaged in external, innovation-based collaboration when firms age. Firms that are part of a foreign multinational or a domestic group generally have a greater propensity to be engaged in alliances. Location also matters: the likelihood-ratio test rejects the constrained specification in which location (province) dummies are jointly set to zero, in favor of the specification with the province dummies (LR = 510.83, p-value< 0.001). In particular, firms located in less populated areas such as provinces in the north of the country, appeared less likely to be engaged in R&D collaboration. In addition, the time and industry dummies (not reported) are jointly significant: the likelihood-ratio test rejects the constrained specification, in which time and industry dummies are jointly set to zero, in favor of the specification with the dummies (LR = 618.42, p-value<0.001).

To test whether there are also differential effects of the past alliance variables between manufacturing and service firms, we applied a Chow test (e.g., Gujarati, 2005, p. 275) by including 6 interaction effects in each equation between a service dummy and the past alliance strategies. The likelihood ratio test (15.29, p-value=0.64) could not reject the null hypothesis these interaction effects are jointly zero. This suggests that there are no systematic

[7] In sensitivity tests, we also examined the impact of an even longer lag between horizontal and vertical alliances, including the variable horizontal alliance engagement in t-6. Such a test requires data on firms in four consecutive surveys, and this more than halves our sample given the underlying sampling process. Competitor collaboration in t-6 was not significant in any of the equations, while the positive and significant coefficients of horizontal alliance engagement in t-4 remained robust. Hence, the empirical regularities seem to point to an effective lag of roughly 4 years.

differences in the role of persistence and interrelation between the manufacturing and services industries in our sample.

Interpretation of findings

Overall, our findings demonstrate that alliance strategies with individual partner types are persistent, that is: past engagement in alliances with a partner type predicts the propensity to be engaged in this type of alliance strategy currently. This corresponds with the various theoretical approaches to alliance formation. Persistence may arise from alliance collaboration experience (Gulati, 1999) and the possibility to capture relational rents (Dyer and Singh, 1998), through the establishment of (collaborative) habits and routines (Cyert and March, 1963), and through network embeddedness (Gulati 1995a; Gulati and Garguilo, 1999). However, while these perspectives endorse the omnipresent role of persistence, the literature has not provided a more in-depth understanding of the differences in persistence of, and interrelation between, alliance strategies with different partner types. Below, we explore a number of possible explanations for the observed patterns that draws on the various views and, in addition, borrows insights from the innovation literature.

First, customer alliance strategies are most persistent. Here an explanation may be sought in the notion in the innovation literature that demand-pull forces tend to be strong determinants of innovative activities (e.g. Dosi, 1988). Collaboration with customers is generally considered to be useful throughout the entire innovation process (Dosi et al., 1990; Von Hippel, 1988). This applies both to its early phases in which collaboration with lead users can provide firms with access to novel ideas that may be indicative of a (large) future market (Von Hippel, 1978) or where they may act as partners in co-creation (Prahalad and Krishnan, 2008), and to its later phases with their emphasis on gaining market acceptance for the new innovation and stimulating its wider diffusion (Dosi et al., 1990; Tidd et al., 2005).

In addition, a governance view suggests that spillover risks in customer alliances are relatively limited when compared to collaboration with suppliers or competitors. Collaboration with suppliers may lead these to become more qualified and hence more attractive as partners to competitors, potentially enabling the latter to free-ride on the investments made by the focal firm (Park and Russo, 1996; Mesquita et al., 2008). Although risks of opportunism and the prevention of leakage of proprietary knowledge may lead firms to vertically integrate, this comes at a price of reduced flexibility and (high) integration costs (Williamson, 1975; Argyres 1996). An alternative strategy may be formed by collaboration based on which these risks can also be reduced through partnership exclusive arrangements and relational governance between the focal firm and its supplier(s) (Zaheer and Venkataraman, 1995; Mesquita et al., 2008). However, this may not contribute to persistence of alliance strategies with suppliers. Instead, when suppliers are engaged in the innovation process, a more temporary and sometimes ad-hoc type of collaboration may often be considered as more appropriate, with a clearly focused and project-based form (Andersen, 1999). In addition, an increasing dependence of a focal firm on collaboration with, and an elevated risk of knowledge spillovers through, suppliers will increase the inclination to consider alternatives to collaboration, such as internal development or market procurement (Gulati et al., 2005). Hence, whereas collaboration with suppliers may be attractive for the focal firm, the risk of spillovers and its corresponding remedial measures may reduce the persistence of a supplier alliance strategy. Although the risk of spillovers can also be present in collaboration with customers, these may be outweighed by the strategic value of access to (scarce) information on specific customer needs and the higher likelihood of initial market acceptance and (future) commercial success. This is different in case of collaboration with competitors in which the risk of undesirable knowledge spillovers is particularly present. Due to relatively similar knowledge bases and competences, competitors may have a greater

capacity for absorption and appropriation of knowledge spillovers, creating a temptation for free-ridership (Park and Russo, 1996; Khanna et al., 1998; Nooteboom, 2004b). This is also related to the idea of 'coopetition' in alliances according to which the cooperative aspect refers to the creation of common knowledge that is shared between partners whereas the competitive aspect refers to the use of this common knowledge to make private gains in an attempt to outperform the partner (Khanna et al., 1998; Ritala, 2009). As a consequence, collaboration with competitors comes with more risks than collaboration with customers, mitigating a firm's propensity to be engaged in competitor alliance strategies.

Second, our results indicate that firms engaged in supplier (customer) collaboration are likely to engage in customer (supplier) alliance strategies in a subsequent period. These findings are consistent with the idea in the supply chain literature that alliances with suppliers and customers are often not pursued in isolation but may be interrelated due to the potential advantages of value chain integration offered by such collaboration (Vickery et al., 2003; Frohlich and Westbrook, 2001). This may be attractive because it offers the possibility for realizing product innovations and/or implement process improvements in a more rapid, cost effective and integral manner (Choi and Hartely, 1996; Fisher, 1997; Childerhouse et al., 2002; Rosenzweig et al., 2003).

The advantages of innovation collaboration through the value chain also suggest that simultaneous engagement in customer and supplier alliances are likely to be beneficial and persistent. We explored this by estimating an equation with the propensity to engage in a *joint* supplier and customer alliance strategy as the dependent variable and we report on this in the Appendix. We find that past joint supplier and customer alliance strategies have a strong and significant effect on current joint alliance strategies. The estimated coefficients indicated that this persistence is significantly greater than the coefficients estimated for individual alliance strategies in Table 2: the coefficients on the past joint terms suggest that their combined effect

is 20-30 percent higher than the combined effect of the t-2 and t-4 coefficients measuring persistence of individual alliances with suppliers or customers. In addition, past (t-2) alliances with either customers or with suppliers have a positive impact on simultaneous alliance strategy with suppliers and customers, suggesting that firms engaged in supplier (customer) collaboration are likely to add customer (supplier) cooperation in a subsequent period.

The strong persistence of joint supplier customer collaboration is consistent with the view that stronger alignment between collaboration with suppliers and customers may contribute to realizing the potential offered by value chain integration, such as the elimination of operational inefficiencies (e.g. 'bullwhip' effects due to demand variability), the reduction of defects, the lowering of total value chain costs, an increase in product differentiation and an acceleration of product development cycles ((Diez-Vial, 2007; Lee et al., 1997; Gulati and Sytch, 2007; Choi and Hartely, 1996; Childerhouse et al., 2002). In addition, stronger alignment may also contribute to the development of shared interests among partners that reduces room for conflict and contributes to the build-up of trust, further diminishing risks of spillovers and/or free-ridership (Nooteboom, 2004b). In this way, joint collaboration further solidifies vertical coordination and knowledge exchange that may contribute to lowering the costs and/or increasing the perceived value of their offerings (Dyer and Singh, 1998; Gulati and Sytch, 2007), and may enhance the development of more complex and broadly based dynamic capabilities encompassing the entire value chain (Teece et al., 1997; Stalk et al., 1992).

The third observed pattern suggested that past engagement in alliances with competitors increases the propensity to be engaged in an alliance strategy with customers and suppliers but with a longer lag (t-4) when compared to the interrelationship between collaboration with suppliers and customers (strongest for t-2). An interpretation for this pattern starts from the notion that the objectives and performance effects of vertical alliances

often differ from those of horizontal alliances. Here, prior studies have demonstrated that alliances with competitors are often most effective for the generation of new-to-the-market products, while supplier and customer alliances tend to impact on productivity growth and incremental product improvements (Belderbos et al, 2004a; Faems et. al, 2005). This suggests that the two types of alliances may complement each other and that some degree of alignment between horizontal and vertical collaboration contributes to the development of dynamic capabilities that enables firms to accomplish new forms of competitive advantage in order to address changing environmental demands (Teece et al., 1997; Eisenhard and Martin, 2000). On the other hand, a governance view highlights the risk of undesirable knowledge spillovers and freeridership, especially in case of collaboration with competitors (Ahuja, 2000b). This suggests important risks and drawbacks of a combined vertical and horizontal alliance strategy. However, the governance risks are foremost an issue if the two types of collaboration overlap in time, such that the focal firm functions as the bridge between competitors and vertical partners. At the same time, the complementary relationship suggested by the competence view leaves open the possibility of reaping the benefits by combining horizontal and vertical collaboration in a more consecutive manner. Established insights from the innovation and (product) life cycle literature provide such arguments for consecutive alignment benefits where it concerns the transition from horizontal to vertical alliances.

In the innovation literature on technology life cycles, it is argued that an initial focus on exploration, with its emphasis on creativity and small-scale experimentation, makes room for a focus on exploitation characterized by a focus on efficiency and (large scale) commercialization (Abernathy and Clark, 1985; Abernathy and Utterback, 1978; Anderson and Tushman, 1990). Seen in this light, horizontal alliances may be particularly well suited for exploration while vertical alliances may be considered as especially useful for

exploitation. The literature on exploitation and exploration has suggested that these may then be optimally combined through a 'punctuated equilibrium' strategy, formed by temporal separation between the two activities (Burgelman, 2002; Gupta et al., 2006). In contrast, the alternative strategy of 'ambidexterity' formed by organizational separation between the two activities at the same point in time will not mitigate the governance risks of combining the two types of alliances (Gupta et al., 2006). Moreover, temporal separation does not need to be harmful for exploration. On the contrary, it can enhance the explorative nature of horizontal collaboration by providing seclusion from current markets and established practices. In this way, more room is offered to maneuver and experiment freely and to obtain novel inspiration and insights from new and disruptive developments that typically emerge beyond the boundaries of an established industry (Gilsing, 2005). Simultaneous collaboration with customers and/or suppliers with its a strong(er) exploitation focus may hamper this and may increase the risk of missing out on such newly emerging key trends in new technologies and markets. These considerations on inter-temporal relations between horizontal and vertical alliances do not play a role in the case of interrelation between supplier and customer alliances. On the contrary, a longer lag in this case would cause a delay that inhibits the alignment of collaboration with suppliers and customers that is required for accomplishing the strategic objectives of vertical collaboration.

Finally, we found positive effects of past customer alliances with a longer lag (t-4) and of recent past supplier alliances (t-2) on the propensity to be engaged in competitor alliances. A tentative interpretation for these findings may be that alliances with customers and/or suppliers can also form an important source of highly new ideas that may possibly go (well) beyond the price-performance ratio of established technology (Christensen, 1997). Such ideas can be several such as, for example, insights into how current products and/or processes, based on established technology, fail to address existing customer needs (Christensen and

Bower, 1996). But also insights into latent customer needs that remain unmet (Aaker, 1996), insights into the limitations of suppliers' (technological) capabilities or, alternatively, into their unrealized innovative potential (Tidd et al., 2005) may form sources of highly innovative ideas. Capitalizing on these ideas may induce a need for the creation of a next-generation technology, possibly in collaboration with competitors (Christensen et al., 2002). In this way, accumulated insights on future opportunities for innovation, as obtained from collaboration with customers and/or suppliers, may serve as an inducement to initiate collaboration with competitors for the creation of next-generation technology. If vertical collaboration precedes horizontal collaboration in time, in a similar vein as discussed above, governance risks related to overlapping alliance strategies can be significantly reduced, without sacrificing the combinatory benefits of vertical and horizontal alliances. So, the interrelationship between horizontal and vertical alliances may contribute - in either way - to the development of dynamic capabilities that enable firms to strengthen and renew its competitive advantage in order to meet (rapidly) changing environmental demands (Teece et al., 1997; Eisenhard and Martin, 2000).

CONCLUSION AND DISCUSSION

Empirical tests on a large panel set of innovating firms in the Netherlands provided first of all support for the idea that alliance strategies with different partner types exhibit different degrees of persistence. Customer alliance strategies exhibit a higher degree of persistence than supplier or competitor alliance strategies, which could be attributed to the strategic importance of customers as collaboration partner throughout the innovation process whereas this comes with relatively limited governance risks. These risks constitute a greater concern in collaboration with suppliers and competitors, mitigating a firm's propensity to be engaged in suppliers and competitor alliance strategies.

Second, our findings showed that alliance strategies with different partner types are interrelated and that such interrelation effects are not necessarily less pronounced than persistence effects. We observed two patterns of interrelationships. First, there is an important interrelation between the two types of vertical alliance strategies (collaboration with suppliers and customers). Past supplier collaboration predicts current customer alliance strategies and vice versa, while the strongest and most significant persistence was found for a joint supplier and customer alliance strategy. These results are consistent with the notion that a combined supplier-customer alliance strategy may contribute to the development of dynamic capabilities encompassing the entire value chain (Teece et al., 1997; Stalk et al., 1992) as well as with earlier findings that firms persistently pursuing an integrative collaborative strategy with suppliers and customers tend to exhibit superior performance (Narasimhan and Jayaram, 1998; Vickery et al., 2003; Frohlich and Westbrook, 2001; Rosenzweig et al., 2003). Second, the analysis revealed a specific pattern of interrelation between horizontal and vertical alliance strategies. Prior engagement in horizontal alliances consistently affected the propensity of engagement in supplier and/or customer alliance strategies with a longer (4 years) lag, while no impact was found for effects with a shorter lag (2 years). These findings are in line with our conjecture that a longer lag allows for a sequence of discovery and experimentation in horizontal collaboration followed by upscaling and commercialization in vertical collaboration in such a way that governance risks can be mitigated while combinatory resource benefits can still be reaped. The pattern resembles a 'punctuated equilibrium' strategy to combine exploration and exploitation through a temporal separation between the two activities (Burgelman, 2002; Gupta et al., 2006).

In conclusion, our findings suggest that alliance strategies with different partner types are interrelated. This is an interesting new insight that stands in contrast with the compartmentalized approach taken in most of the literature until now. Prior studies have often

tended to focus on one type of alliances at a time or have implicitly considered horizontal alliances and vertical alliances as unrelated. Instead, our study shows that differences in partner attributes along partner types do matter and cannot be ignored, as evident interdependencies operate across them.

We see several suggestions and possible avenues for future research as they arise from our findings. First, while interdependencies between different alliances have been studied in the portfolio approach to alliances (Hoffman, 2007; Vassolo et al, 2004; Wassner, 2009; Lokshin and Duysters, 2008), relationships between alliances with different partner types have not received due attention in prior studies. What seems to emerge from our analysis is that while the portfolio approach examines simultaneous strategies, some particular alliance configurations may be more effective if combined in a more sequential manner, to reduce governance risks and to avoid conflict. This is partially related to the notion of sub-additivity or conflict in alliance portfolios (Vassolo et al, 2004; Wassmer, 2009) where combining certain types of alliances may lead to suboptimal results. Yet our findings indicate that in some cases, alternating alliance strategies and an inter-temporal portfolio approach may solve such critical issues related to simultaneous alliance strategies. The understanding of the role of such interdependencies is important as they serve as critical determinants for the extent in which a firm derives value from its portfolio (Wassmer, 2009). Clearly, combining an inter-temporal and simultaneous dimension of alliance portfolios suggests a promising avenue for future research.

Our study also reflects on the network perspective on alliances. Whereas the findings are in line with the general wisdom that firms sharing strategic interdependence are more likely to engage in alliances when compared to non-interdependent firms (Stuart, 1998; Gulati and Gargiulo, 1999), our study could be seen to extend this commonly held idea in a number of ways. We show that persistence in alliance strategies with a specific partner type is not

only shaped by bilateral dependence but also by interdependence with other partner types. Whereas until now collaboration has been considered as operating between firms from only two interdependent 'strategic groups' (Chung et al., 2000; Gulati and Garguilo, 1999), our findings suggest that an alliance strategy with a specific partner type is also affected by other strategic groups from which different partner types originate. Furthermore, our study sheds some more light on how interrelationships between alliances types and time elapsed are related. The findings on the relationship between horizontal and vertical alliance strategies, suggested that a degree of delay can increase the propensity to be engaged in vertical collaboration rather than reduce it. This finding is consonant to the curvilinear effect of time elapsed on alliance formation found in pioneering work by Gulati (1995b). Whilst this effect was unexpected from a network embeddedness perspective in his study, the combination of a competence and governance perspective as taken in our study suggests that some delay enables to mitigate risks whereas too much delay sacrifices combinatory benefits.[8]

Our explorative research had a number of limitations, which could be addressed in future work. An important limitation was that the panel data set used does not identify alliance partners by name, such that we could not distinguish whether persistence is with the same or different firms within alliances types. The explanations that we proposed for partner type persistence and interrelation in collaboration were therefore broader and related to innovation processes and strategic collaboration needs as well as to governance issues pertaining to collaboration with a category of partners, within which firms may substitute a specific partner firm. A different research approach utilizing longitudinal datasets identifying partner names as well as partner types would allow texamining differences in persistence across the same type and for the same partner. Another issue for future research is to develop an integrated theoretical perspective that allows to distinguish between, and to assess the

[8] Interestingly enough, the optimum delay that he finds is approx. 3.8 years. This is very close to the four year lag that we found to be robust in our analysis.

contingent importance of, the various theoretical streams from which hypotheses on persistence and interrelation between alliance types may be derived. Empirical test could then focus on the firm level antecedents of (differences in) persistence, and provide insights beyond the general patterns described in this paper.

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TABLE 1 Descriptive statistics and correlation matrix among variables used in model (N=4632)

	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	16	15
1 CUSt;	0.10	0.30	1.00													
2 SUPt	0.13	0.34	0.68	1.00												
3 COMt	0.07	0.25	0.56	0.53	1.00											
4 CUSt-2	0.10	0.30	0.20	0.19	0.12	1.00										
5 CUSt-4	0.09	0.29	0.15	0.15	0.13	0.16	1.00									
6 SUPt-2	0.12	0.33	0.22	0.23	0.15	0.59	0.14	1.00								
7 SUPt-4	0.11	0.31	0.11	0.12	0.10	0.15	0.51	0.17	1.00							
8 COMt-2	0.07	0.25	0.15	0.15	0.14	0.51	0.09	0.48	0.10	1.00						
9 COMt-4	0.07	0.25	0.10	0.11	0.10	0.09	0.40	0.07	0.38	0.14	1.00					
10 R&Dt-2	0.03	0.17	0.11	0.12	0.10	0.13	0.11	0.14	0.11	0.13	0.12	1.00				
11 R&Dsqt-2	0.03	1.40	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.06	0.06	0.87	1.00			
12 SIZEt-2	4.81	1.04	0.18	0.21	0.18	0.17	0.17	0.19	0.19	0.14	0.14	0.06	0.03	1.00		
13 MNEt	0.34	0.47	0.06	0.09	0.05	0.11	0.04	0.12	0.04	0.07	0.03	0.03	-0.01	0.09	1.00	
14 DOM GROUPt	0.51	0.49	0.03	0.04	0.03	0.01	0.02	0.02	0.02	0.00	0.01	0.00	0.02	0.03	-0.73	1.00
15 AGEt	26.27	10.78	-0.07	-0.05	-0.06	-0.03	-0.05	-0.02	-0.02	-0.02	-0.04	-0.05	-0.02	-0.05	-0.01	0.03

Table 2 Multivariate probit analysis of the propensity to form technology alliances

	Customer alliance	Supplier Alliance	Competitor alliance
	(1)	(2)	(3)
CUS_{t-2} (Customer alliance in t-2)	0.34*** (0.07)	0.13† (0.08)	-0.02 (0.14)
CUS_{t-4} (Customer alliance in t-4)	0.50*** (0.11)	0.39*** (0.11)	0.41** (0.14)
SUP_{t-2} (Supplier alliance in t-2)	0.24*** (0.08)	0.33*** (0.07)	0.16† (0.08)
SUP_{t-4} (Supplier alliance in t-4)	-0.06 (0.08)	0.01 (0.11)	0.00 (0.08)
COM_{t-2} (Competitor alliance in t-2)	0.08 (0.12)	0.09 (0.08)	0.30** (0.12)
COM_{t-4} (Competitor alliance in t-4)	0.21* (0.10)	0.24** (0.07)	0.15† (0.09)
$R\&D_{t-2}$ (R&D intensity in t-2)	3.41*** (0.68)	3.11** (0.66)	3.14*** (0.46)
$R\&Dsq_{t-2}$ (R&D intensity squared in t-2)	-1.67** (0.65)	-1.51* (0.64)	-1.48*** (0.51)
$SIZE_{t-2}$ (Firm size in t-2)	0.21*** (0.03)	0.23*** (0.03)	0.23*** (0.03)
AGE_t (Firm age in t)	-0.01* (0.00)	-0.01* (0.00)	-0.01* (0.00)
MNE_t (MNE in t)	0.25** (0.08)	0.27*** (0.10)	0.17* (0.09)
$DOM\ GROUP_t$ (part of domestic group in t)	0.15* (0.06)	0.15 (0.09)	0.06 (0.08)
Constant	-3.76*** (0.21)	-3.17*** (0.24)	-3.41*** (0.19)
Rho/2	0.88*** (0.02)		
Rho/3	0.81*** (0.03)	0.79*** (0.03)	
Time dummies	Included	Included	Included
Industry dummies	Included	Included	Included
Location (province) dummies	Included	Included	Included
Number of firms	3181	3181	3181
Number of observations	4632	4632	4632
Wald $\chi^2(39)$, p-value< 0.001	671.49		
Log-likelihood	-2581.53		

Notes: Robust standard errors in parentheses
† p<0.1 (Significant at 10% level)
* p<0.05 (Significant at 5% level)
** p< 0.01 (Significant at 1% level)
*** p< 0.001 (Significant at 0.1% level)

Appendix: Probit analysis of the propensity to form customer & supplier technology alliances

	Customer alliance	Supplier Alliance	Competitor alliance
	(1)	(2)	(3)
CUS_{t-2} *(Customer alliance in t-2)*	0.34*** (0.07)	0.13† (0.08)	-0.02 (0.14)
CUS_{t-4} *(Customer alliance in t-4)*	0.50*** (0.11)	0.39*** (0.11)	0.41** (0.14)
SUP_{t-2} *(Supplier alliance in t-2)*	0.24*** (0.08)	0.33*** (0.07)	0.16† (0.08)
SUP_{t-4} *(Supplier alliance in t-4)*	-0.06 (0.08)	0.01 (0.11)	0.00 (0.08)
COM_{t-2} *(Competitor alliance in t-2)*	0.08 (0.12)	0.09 (0.08)	0.30** (0.12)
COM_{t-4} *(Competitor alliance in t-4)*	0.21* (0.10)	0.24** (0.07)	0.15† (0.09)
$R\&D_{t-2}$ *(R&D intensity in t-2)*	3.41*** (0.68)	3.11** (0.66)	3.14*** (0.46)
$R\&Dsq_{t-2}$ *(R&D intensity squared in t-2)*	-1.67** (0.65)	-1.51* (0.64)	-1.48*** (0.51)
$SIZE_{t-2}$ *(Firm size in t-2)*	0.21*** (0.03)	0.23*** (0.03)	0.23*** (0.03)
AGE_t *(Firm age in t)*	-0.01* (0.00)	-0.01* (0.00)	-0.01* (0.00)
MNE_t *(MNE in t)*	0.25** (0.08)	0.27*** (0.10)	0.17* (0.09)
$DOM\ GROUP_t$ *(part of domestic group in t)*	0.15* (0.06)	0.15 (0.09)	0.06 (0.08)
Constant	-3.76*** (0.21)	-3.17*** (0.24)	-3.41*** (0.19)
Rho/2	0.88*** (0.02)		
Rho/3	0.81*** (0.03)	0.79*** (0.03)	
Time dummies	Included	Included	Included
Industry dummies	Included	Included	Included
Location (province) dummies	Included	Included	Included
Number of firms	3181	3181	3181
Number of observations	4632	4632	4632
Wald $\chi^2(39)$, p-value< 0.001	671.49		
Log-likelihood	-2581.53		

Notes: Robust standard errors in parentheses
† p<0.1 (Significant at 10% level)
* p<0.05 (Significant at 5% level)
** p< 0.01 (Significant at 1% level)
*** p< 0.001 (Significant at 0.1% level)